

The HAWAIIAN PLANTERS' RECORD

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The

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L. D. Bayer, Editor

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Cover Picture—*"For some years we have been in need of more room for our Station activities. Now we have two new buildings added to our facilities. They will prove of great value. Today we dedicate them to the service of the sugar industry of Hawaii"* . . . Dr. A. L. Dean, Experiment Station executive committee member, at the 1948 HSPA meeting unveiled plaques bearing the names of two former Station directors, H. P. Agee and H. L. Lyon, and announced that the two new buildings at the Station were to be dedicated to them. Top picture shows Agee hall, the auditorium building, lower picture is Dr. Dean presenting the plaque for Lyon hall to Dr. Bayer.

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Must Actual Yields Trail Research Results?

By L. D. Baver¹

Why does not the production on an acre of land under actual farming practices equal, or even approach, that which should be expected from the results of scientific research? Research workers in the laboratory, the greenhouse and the field develop better plants with higher yielding characters; they improve the methods of culture and fertilization; they improve means for protecting the crop against insects, diseases and drought, and they get large increases in yields as shown by the results of field experiments. But, out in the field, averaging all the lands planted to a given crop, the percentage increase in yields generally does not even approach closely the theoretical expectations. The question naturally follows as to the causes of this lag between science and practice.

SCIENCE VERSUS PRACTICE IN THE CORNBELT

THE If we take Ohio as a typical
FACTS cornbelt state and look at the yields of various crops from 1870 to 1930, for example, some rather interesting facts are brought out. During this 60-year period, corn yields for the state as a whole increased only 0.3 bushel per acre; oat yields increased 7.4 bushels; wheat 3.2 bushels, and hay 0.12 ton. In the 20-year period beginning in 1910 and ending in 1930, corn yields were the same; oat yields decreased 1.1 bushels per acre; wheat yielded 1.0 bushel less, and hay increased by 0.05 ton per acre. In other words, in spite of the increased acreage of tile-drained land, improved varieties, improved farm machinery, better pest control, an increase in the use of lime, fertilizers and legumes, and the discarding of thousands of acres of poor land from crop production, crop yields were barely holding their own.

If wheat yields are analyzed more closely, it is seen that the late twenties only showed a 3.2-bushel per acre increase over the late seventies. On the other hand, four-fifths of the farmers were using varieties that should have given three bushels more per acre. At the same time wheat was being fertilized with 180 pounds of fertilizer which hundreds of field tests showed should have produced another seven bushels of wheat. But, instead of getting a 10-bushel increase in wheat production, only a 3.2-bushel-increase was realized. The only answer to this difference between the expected and achieved yields is that the "*natural productive capacity of the soil has been deteriorating at a rate almost fast enough to offset all the improvements in soil and crop management.*" Results of the Ohio calculations are shown in **Figure 1**. It is clearly illustrated that

¹ L. D. Baver is director of the Experiment Station, HSPA.

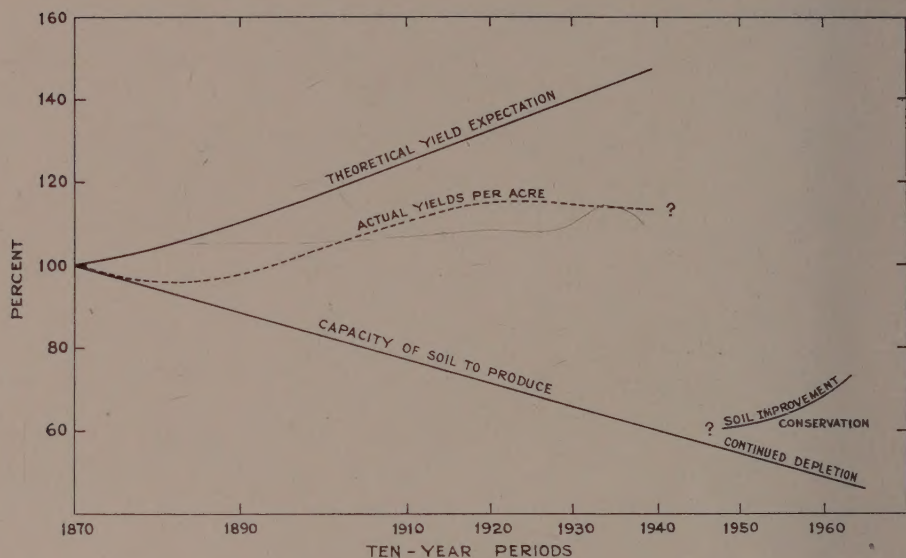


Figure 1. Actual versus theoretically expected crop yields in the cornbelt.

the actual yield increases have been less than half of the theoretically expected ones. Since the curve for actual yields is considerably below the theoretical, it means that negative factors have been at work which bring yields down. In the case of corn, it is soil depletion, or the capacity of the soil to produce.

THE CAUSES Analysis of soil conditions throughout the state showed that cropped lands had lost about a third of the original amount of organic matter. Continued cropping had made soils that were originally sweet become rather acid. The physical condition, or tilth of the land had deteriorated so much that there was about 22 per cent more soil in a cubic foot than originally. This reduced aeration, increased the need for drainage and made handling operations in planting and taking care of the crop more difficult. Erosion also had taken a sizable toll from all farms that were not flat. It had removed some of the most valuable topsoil from the fields.

By using yield data from long-time experiments dating back to 1894 and by making supplementary chemical analyses of the soil, it was possible to evaluate various cropping systems and cultural practices from the standpoint of their effects upon the soil. Productivity indexes were assigned to the various practices on the basis of their annual effects. Several of the more important indexes are shown on the following page.

There are several interesting points in this table. First, it is obvious that soil depletion is continuous unless something is returned to the soil. Second, it is clear that cultivated row crops are the most highly depleting. Third, the loss of productivity cannot be offset with commercial fertilizers unless extremely heavy applications are made. For example, it will take one and one-third tons of a 20-unit fertilizer to offset the depleting effects of one crop of corn. Fourth, erosion can offset the beneficial effects of other soil-conserving practices.

Practice	Productivity Index (Decrease or increase in % per year)
1. Cultivated row crops, such as corn, potatoes, tobacco, sugar beets....	-2.0
2. Small grains.....	-1.0
3. Sweet clover and first year alfalfa.....	+2.5
4. Grass-legume sod as hay or pasture.....	+1.0
5. Crop residues returned.....	+0.25
6. Each ton of manure applied.....	+0.15
7. Each 200 lbs. of 20 unit fertilizer.....	+0.15
8. Erosion	
slight.....	-0.25
moderate.....	-0.50

THE REMEDY From the foregoing it might appear that soil deterioration and depletion are inevitable. That is not the case at all. It is true that under continuous culture of a row crop, it is quite difficult to maintain productivity. The Ohio Station has found that with a good rotation, including high-type legume sods, prompt return of manure, liberal use of lime and fertilizers and control of erosion, yields can be had that are twice those of the average farm of the state. Maintenance of good erosion control practices through contour farming, strip cropping and other

practices can minimize the harmful effects of rain. The secret, however, to soil improvement is the liberal use of organic residues to maintain a suitable environment for growth of the crop. The question confronting the cornbelt farmer, as shown in **Figure 1**, is to decide now if he is going to allow his basic resource to continue on the road to complete depletion, if he will just try to conserve what he has so that it will not get any worse, or if he will begin an improvement program that will increase his yields.

ANALOGIES IN THE SUGAR INDUSTRY

It is of interest to know if the same general trends found in the production of corn also apply to sugar cane in Hawaii. Therefore, the problem was approached in two ways.

First, theoretical yields were estimated by plotting the increases in sugar produced per acre in field experiments when the variety H-109 replaced Lahaina and when 32-8560 took the place of H-109. Then from this same area the average yields from two irrigated plantations on which these varieties were grown were plotted for each five-year period beginning with 1908.

Second, the period 1908-1912 was used

as a base and the yields of sugar for the industry as a whole were calculated on a relative basis for each five-year period since that time. Sugar yields were calculated in the usual manner of sugar per acre of cane harvested and also on the basis of amount of sugar per acre of land in cane. From the information thus obtained it is possible to show several rather significant relationships between time and sugar yields.

STATUS OF YIELDS Examine first the curves in **Figure 2**, which show the obtained yields on two irrigated plantations in comparison with

the theoretical. It is observed that only in the late twenties and early thirties on plantation 1 did the actual yields approach the theoretical, as calculated from variety increases alone and without taking into consideration any improvements in cultural practices and fertilization.

Average yields for plantation 1 and plantation 2 for the 10-year period, 1908-17, were 7.1 and 6.2 tons of sugar per acre harvested, respectively. This was the period when Lahaina was the main variety on the plantations cited. During this same period, yields obtained from variety tests in the same area average about 9.7 tons. The theoretical yield was from 35 to 50 per cent higher than those obtained on the two plantations. When H-109 replaced Lahaina in the late

twenties, yields on plantation 1 increased to 11.7 tons; those on plantation 2 went up to 9.7 tons. Not all these increases, however, can be attributed to the new variety. There were influences of changes in cultural practices and perhaps favorable climatic effects also played a part. Plantation 1 was within about 5 per cent of the theoretical curve at this point; plantation 2 was within about 20 per cent.

The significant part of these curves is the trend of plantation 1 from the late twenties until now. There has been a steady decrease in sugar yields during the past ten years from a five-year high of 11.9 tons in the 1935 period to 9.8 in the 1945 period. Theoretical yields have increased as 32-8560 took over to a high

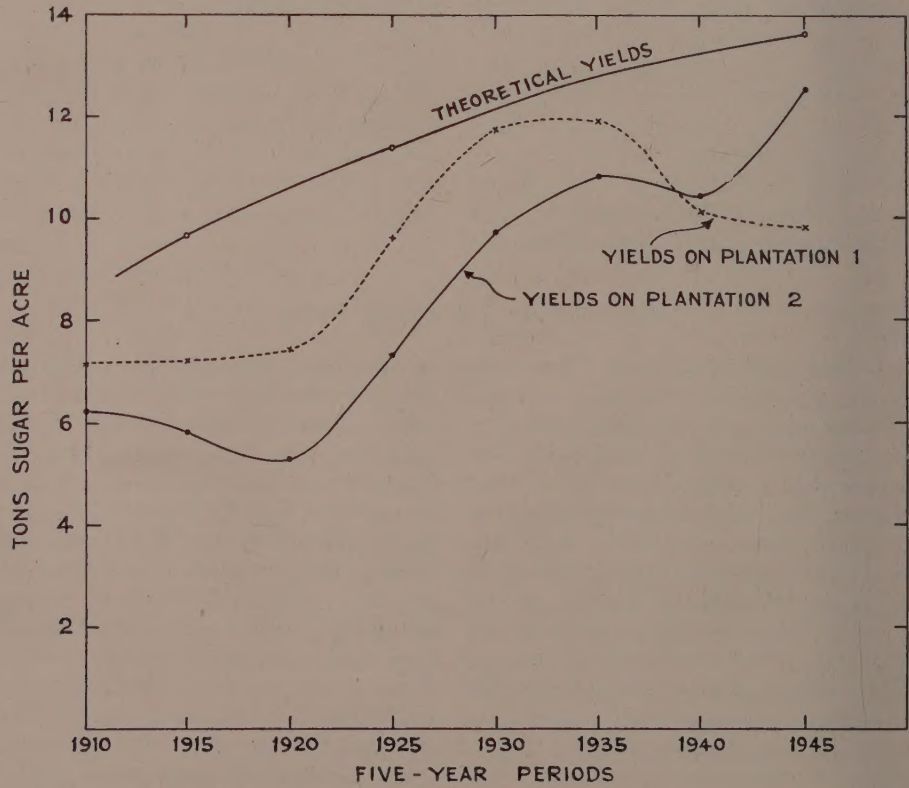


Figure 2. Five-year average sugar yields over a 40-year period on two irrigated plantations.

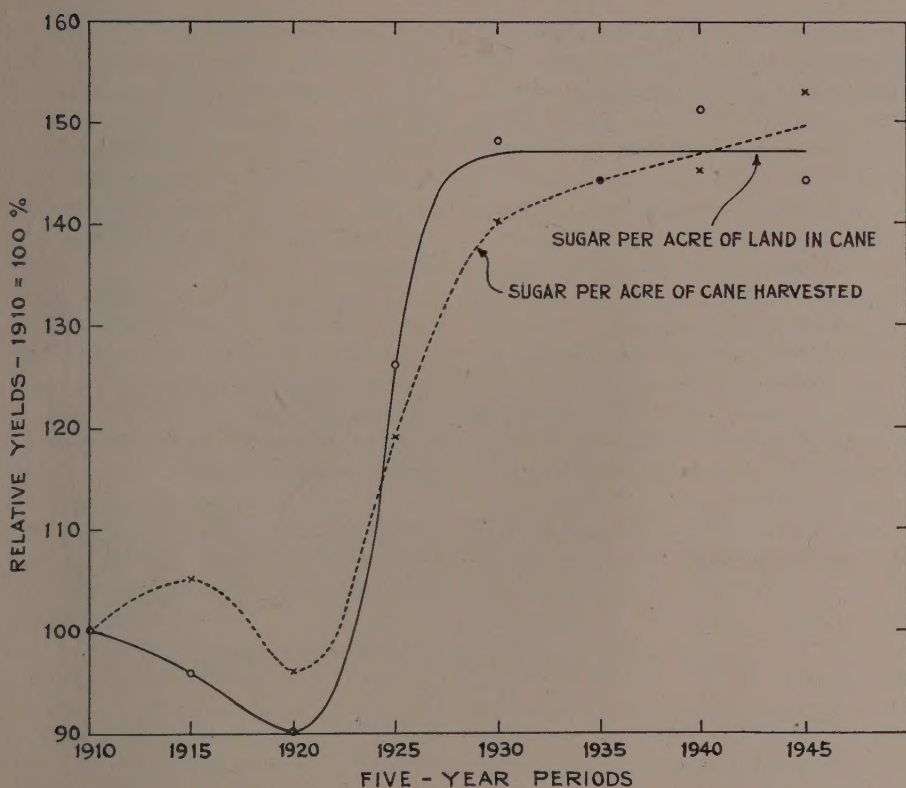


Figure 3. Relative sugar yields for the sugar industry, with 1908-12 as the base period.

of about 14 tons. This means that in 1945 yields on plantation 1 were only within about 40 per cent of the theoretical. Plantation 2, on the other hand, has shown a steady increase in yields to a high of 12.5 tons per acre in the 1945 period. At this point the plantation was about 10 per cent from the theoretical. Results on both plantations show that negative factors have been at work that have prevented them from attaining the expected yields. The negative factors have been more highly expressed on plantation 1.

Results in **Figure 3**, give an even more interesting picture of what has been happening to sugar yields during the past 40 years. These curves are based upon the amount of sugar produced per acre of

land that is planted in cane, as well as the yields per acre of cane harvested.

The presentation showing the amount of sugar in the bag in terms of the entire land area used for cane is not used much in sugar production discussions. Nevertheless, it does show how the acres of soil on which cane is grown are keeping up in their productivity.

Let us first look at the curve showing the amount of sugar produced per acre of cane harvested. During the base period, 1908-12, the average yields of sugar were 5.03 tons per acre. There was about a 4 per cent decrease during the 1920 period. However, ten years later, the 1930 period, average yields had soared to 40 per cent above the base period. Average yields at this time were 7.04 tons

per acre for the industry as a whole. From 1930 until the last five-year period, the yield curve has risen only slightly. Compared with the base period, yields have been 53 per cent higher. Referred to 1930 they have risen only about 9 per cent. The 1945-period average yields were 7.68 tons. When one compares these increases with those to be expected from improved varieties alone, it is found that the increase up to the 1930 period approximates the percentage increase in the theoretical curve fairly closely. However, since 1930 the varietal picture indicates that about a 20 per cent increase should have been achieved instead of the 9 per cent.

Now let us examine the other curve giving yields in terms of sugar produced per acre of land in cane. During the 1908-12 base period, the average yield was 2.7 tons of sugar for every acre of land planted to cane. There was about an 11 per cent decrease in yields during the 1920 period. The next ten years showed the remarkable increase of 48 per cent over the original base period. At this time the industry was putting four tons of sugar in the bag for every acre of land that was planted to cane. During the next three five-year periods, however, this yield has not changed significantly, although there has been a slight fluctuation between 3.9 and 4.1 tons per acre.

The slight discrepancy between the two curves may fall within the usual error in the compilation of figures or be due to abnormalities in the harvesting schedules. Nevertheless they do bring out the fact that yield increases as measured by sugar in the bag have not kept pace with other developments.

DISCUSSION An analysis of the **OF STATUS** curves in **Figures 1, 2 and 3** clearly indicates that the same general tendencies exist in the produc-

tion of sugar cane as in the growing of corn. In other words, even in the sugar industry, where the possibility of changing practices should be more easily realized than in the cornbelt where so many farmers are concerned, there is a lag between scientific developments and the achievement of maximum results in the field.

The question naturally arises as to the probable causes of the slight, if any, increases in industry-wide sugar production during the past 15 to 20 years. When one compares the curves in **Figure 2** with those in **Figure 3**, it becomes apparent that the flat to almost flat curves in **Figure 3** are the composite result of some plantations falling off in their production, some just holding their own, and others making some increase.

Undoubtedly, there have been changes in soil productivity with time. It is very difficult to present cold facts to back up this statement. However, certain observations taken from different segments of the industry would justify such a conclusion. There can be no denying that appreciable quantities of valuable topsoil are being lost by erosion from the sloping lands of plantations in the unirrigated areas. The detrimental effects of erosion increase with the shallowness of the surface soil and its inherent productive capacity. This usually means that the effects on yields will be slight but consistent on the better soils and more obvious on the poorer ones.

It is a matter of conjecture as to what effects heavy machines will have on the productive capacity of the soil over a period of time. This will vary with the nature of the soil. Nevertheless, it is certain that these effects would not be listed on the beneficial side. The slowness with which some ratoon crops come along is evidence of at least a temporary deleterious effect.

Another clue to decreased soil pro-

ductivity is the greater cane growth obtained upon those areas that had been retired from cane production, put into pasture for several years, and then plowed up for cane. The soil is loose and friable as compared with a more compact soil on adjacent lands. The cane is making more sugar. In addition, there are the beneficial effects of rotating cane and pineapples on the island of Kauai. When one can tell the difference in soil tilth as late as the first ratoon crop, there must be a pronounced beneficial effect of the pineapple residues on soil tilth and soil productivity.

The large root system of the cane plant is undoubtedly responsible for keeping soil productivity from declining more rapidly. Yet, it is questionable whether the facts are available for making the

maximum use of this extensive root system. The rather heavy usage of commercial fertilizers likewise has its offsetting influences on soil depletion. But, research has shown that soils will not continue to produce to their maximum capacity on commercial fertilizers alone.

Unlike the cornbelt, the sugar industry has the additional problem of losses from the cane plant to the sugar bag. If soil productivity is maintained and not all the sugar manufactured by the plant can be safely transported to the sugar bag, then the resultant effect will be a gap between the actual yields and the theoretically expected ones. There is some evidence to suggest that these losses are sufficient to account for the difference between actual and theoretical yields on some plantations.

CLOSING THE GAP BETWEEN SCIENCE AND PRACTICE

It behooves the sugar industry to take advantage of all available facts to approach more closely the theoretical yield expectation curve. If the facts are not available, it should be the goal of all concerned to obtain this basic information as soon as possible.

CONSERVING SOILS Due to the fact that the culture of sugar cane in Hawaii is at the moment almost a continuous process on the same soil, many techniques employed for soil conservation and improvement in the growing of corn cannot be used. However, it does not necessarily follow that practices not now in use cannot be successfully employed to improve soil productivity.

Let us first analyze the different techniques for controlling erosion in terms of their possible application to sugar cane production. To do this, one must keep in mind the mechanics of the erosion process. First, there must be detachment of the soil particles from the soil mass.

Second, there must be transportation of particles from the land as runoff water leaves the slope. Detachment begins with impact of the raindrop on the soil. The amount of soil in the raindrop splash increases with the drop size, drop velocity and rainfall intensity. The falling raindrop not only detaches the particles from the soil, but the resultant fine particles seal up pores in the soil, compacting the surface and making the soil less permeable to water. This increases runoff and transportation of soil. Some detachment also occurs when water concentrates into rills and gullies. But the main soil losses occur from the washing that takes place as so-called "sheet erosion." If raindrops cannot contact the soil, there will be little if any erosion. Such is the case in forests, pastures, sods or in heavy vegetation.

Critical stages in the growth of sugar cane for serious erosion occur from the time the last ratoon crop is harvested and the next plant crop has closed in. Here the soil is very vulnerable to the

impact of falling rain. A second vulnerable period exists between the time of harvesting and the closing in of the ratoon crop. Erosion control on the sloping lands of the unirrigated cane areas should be aimed to minimize the soil washing during these critical periods.

There are about five different techniques used, either alone or in combination, for controlling erosion. These are terracing, contouring, rotations, strip-cropping and the use of surface residues. Of these methods, terracing is undoubtedly ruled out as having any application in sugar cane growing in Hawaii because of the steepness and unevenness of the slopes involved. The use of rotations, with the possible exception on Kauai where sugar cane and pineapples are being alternated, is seemingly out of the picture in the one-crop system of cane growing.

Strip-cropping, as usually practiced by alternating strips of cultivated and sod crops across the slope, is probably not applicable to sugar cane. However, one should not rule out the possibility of strip-cropping with cane of different ages. The fundamental principle of strip-cropping is to break up the length of the slope and to check the downhill flow of water, deconcentrating it and thereby reducing its capacity to detach and transport particles. For example, the use of strip-cropping in the growing of cotton has shown a reduction of soil losses of from 70 to 90 per cent over the usual methods for growing cotton. Strip-cropping consisted of alternating cotton and small grain in contoured strips across the slope.

It would seem that contouring and the use of residues in the surface offer the best possibilities for erosion control in the vulnerable areas of the Hawaiian sugar industry. Contouring is an old practice for controlling erosion in many parts of the world. It has been practiced in the Southeastern states rather exten-

sively. Contouring, of course, is nothing more than a series of miniature terraces around the slope. Each row carries its own water. Some examples of differences in soil losses under corn farming when the land is contoured will give a fairly clear picture of the opportunities for using this method of control in sugar cane culture. Erosion from corn land on a 12 per cent slope in eastern Ohio was decreased from 57.3 to 15.4 tons of soil per acre by changing the rows from up and down the slope to the contour. On an 8 per cent slope in Iowa, contouring decreased erosion from 27.7 tons per acre to 7.3 tons. Experiments have shown that the more permeable the soil, the greater is the effect of contouring on making the water enter the soil. Increases in yields of from 20 to 30 per cent have been obtained in many instances from contouring alone. Another important feature of contouring is the greater ease of using farm machinery. Tests conducted in Kansas have indicated that savings of about 10 per cent were realized in both fuel and time when a $7\frac{1}{2}$ per cent slope was farmed on the contour rather than up and down the slope.

Observations at Onomea, where contour planting was initiated in 1948, indicate a rather uniform growth of cane on both knolls and low spots. The contoured fields seemed to handle the heavy rainfall of 1948 without much washing. This fact alone should increase the efficiency of surface-applied fertilizers. In light of facts available from the mainland on corn, cotton and other row crops, of observations at Onomea, and of "a priori" reasoning, it would seem that this practice could fit into sugar cane operations in an excellent way to control erosion.

Organic residues in the immediate surface have a tremendous effect upon decreasing soil erosion. Their major effect is to provide a protective blanket over

the soil against the impact of raindrops. They also help to hold the soil together against the cutting action of runoff water. They serve to keep the soil porous so that rainfall will be absorbed and not lost as runoff. An experiment at the Federal Soil Conservation Experiment Station at Zanesville, Ohio, illustrates the effects of surface mulch on erosion. Rain artificially applied at the rate of about 2.25 inches per hour caused soil losses in one hour of about ten tons of soil per acre when the land had no surface mulch. About 79 per cent of the rainfall was lost as runoff. On the mulched plots, only about 0.2 ton of soil and 2½ per cent of the water were lost.

Organic residues can be used on any soil and slope condition. Where slopes are too steep or too uneven to use any other method of control, surface residues are the only solution to the problem of erosion control. Since there is so much trash produced in the growing of sugar cane, these residues can undoubtedly be used as assets in conserving the soil. It is paramount that attention be given toward saving the vital surface soil on many of Hawaii's sugar plantations. Some of the soils in the erosion area are already rather shallow. As the depth of the soil decreases so do sugar yields decline. Once the basic resource is lost, fields must be retired from cane to a state of unproductivity.

IMPROVING SOILS To increase yields we must not only conserve our soil, but also improve its productive capacity. Unless that capacity can be improved on many fields, the industry-wide production of sugar per acre of land planted to cane cannot be increased very much. Many difficulties present themselves toward accomplishing this objective. The productive capacities of mainland soils are improved by using rotations in which a soil-building

sod crop is the key to success. Manures are used to advantage on livestock farms. The beneficial effects of rotations and manures increase greatly the lower the natural productivity of the soil. Their greatest effects have been realized upon those soils that have detrimental physical properties, such as poor aeration, poor drainage and shallowness. However, there are decided benefits on the better soils as well.

How can these facts be used to increase the productivity of sugar cane soils in Hawaii? The answer to that question will require more research under Island conditions. The rotation of sugar cane and pineapples offers possibilities on those Islands where these two crops are grown. Perhaps some technique for incorporating a short soil-improvement crop into the cropping cycle of the cane plant can be devised. It will take research to prove or disprove this possibility. In spite of some facts and observations to the contrary, cane trash surely can be an asset in soil improvement. The inconclusive trash experiments of the past need to be repeated in light of modern information on organic matter decomposition.

CONSERVING SUGAR PRODUCED The amount of sugar stored in the stalks of cane growing on an acre is not synonymous with the number of bags of sugar from that same acre. In other words, losses take place between the harvest field and the bagging operation. Any reduction of these losses will aid materially in closing the gap between expected and actual yields. Facts show that cane is injured when it is push-raked, grab-harvested, grab-loaded and wet cleaned. Injured cane loses juices at the time of injury and during the washing process. Injured cane also loses sucrose by inversion when it is stored even for relatively short periods.

All these facts point to significant sugar conservation that can accrue from a streamlined mechanization program.

Facts are available to serve as guides in the development of that mechanization program. At the moment they may be summarized as follows:

- *Different type cutters are needed for line-irrigated and unirrigated cane.* It is necessary to have a different mechanism to handle cane in a furrow as compared with cane on level ground or on a ridge. Cane that is well anchored cuts differently from that with a shallow root system.
- *Cutting off the cane at the ground must be accompanied by a cutting of the cane into shorter lengths.* Long stalks of cane are susceptible to breaking, bending, buckling, crushing and squeezing that short stalks can escape. Apparently, all long stalks are considerably reduced in length by the time they get through the cleaning plant.
- *Efficient and effective mechanization must eliminate the push rake, the grab harvester and loader, and excessive washing at the mill.* These are all "sugar-losing" operations which must be replaced or so modified as to minimize their injury to the cane.
- *A satisfactory cutter alone only partially solves the problem of sugar losses.* If satisfactory cutting of the cane must be followed by push-rake windrowing and grab-loading, the maximum benefits from cutting will be offset to a very great extent by these subsequent operations.
- *Basic principles for mechanically picking up machine-cut cane have been developed.* Cutting, picking up and
- *Cane can be cleaned in the field so as to remove from a half to three-quarters of the trash present.* Such a machine would not only reduce transportation costs but would also accomplish the objective of keeping the trash in the field for soil conservation and improvement purposes. The removal of trash would also reduce sugar losses in the factory.
- *Cane harvesting and transporting on the very wet soils of the rainy districts must be done with as few ground machines as possible.* Soil puddling and compaction, with their detrimental effects upon ratoon crops, are greater the wetter the soil. The problems in the wet areas are quite different from those of the irrigated plantations.
- *There should be a definite mechanization system for each plantation.* More attention needs to be given to field irrigation, planting and other operations to increase the efficiency of field equipment. Systems are more easily changed than machines. In the corn industry, for example, the corn planter is so designed as to accommodate all subsequent mechanized equipment, including the corn harvester.

It appears that the ascertaining and application of sound, basic facts to the problems of increasing soil productivity and sugar conservation from field to factory should make a sizable contribution to narrowing the gap between science

and practice in the sugar industry. It is not a coincidence that the status of yields in sugar production is so similar to that in the growing of corn. Basic principles in the efficient production of a plant in the soil do not change much in nature from one crop to another, from one soil to another, or from one geographic region

to another. The difference is one of degree or size. Science is not made up of compartments, such as one for corn, one for sugar, one for cotton and one for other crops. Science is a composite of fundamentals. Unless they are understood, they cannot be combined into a program of successful operation in practice.

Differences in Nitrogen Utilization by 32-8560 and 37-1933

By R. J. Borden¹

Since 37-1933 was not included in an earlier study² we had made of varietal differences in nitrogen utilization, and because some of our planters believed that this new variety would need more nitrogen fertilizer than 32-8560, a new study³ was undertaken to determine whether these opinions were justified.

Data are presented to show the manner in which crops of 32-8560 and 37-1933 have utilized their available nitrogen supplies. There is much evidence of similarity in many of the measurements recorded. However, the sugar yields were not increased as the nitrogen levels were raised above the minimum amount available, and the two varieties were equally efficient producers of sugar in a 12-month period at this minimum nitrogen level, with no indication from the cane weights that would point to a difference being found at more advanced ages.

METHOD OF CONDUCTING EXPERIMENT

Cuttings of these two varieties were planted on October 28, in standard sized pots of well mixed Manoa soil which contained 90 ppm of readily available nitrogen (.36 gram N per pot). The soil was

adequately supplied with phosphate and potash, and given four levels of nitrogen fertilizer according to the following schedule:

Nitrogen Level	Grams N per pot applied							Total Gms. N applied
	At planting	At 2 mos.	At 3 mos.	At 4 mos.	At 5 mos.	At 6 mos.	At 7 mos.	
Low.....	2.2	0	.55	0	.55	0	1.1	4.4
Average.....	2.2	0	1.1	0	1.1	1.1	1.1	6.6
High.....	2.2	1.1	1.1	1.1	1.1	1.1	1.1	8.8
Excessive.....	2.2	1.1	1.1	2.2	1.1	2.2	1.1	11.0

With the .36 gram of readily available nitrogen in each pot's soil, the known available nitrogen supply for these four

nitrogen levels was actually 4.76, 6.96, 9.16, and 11.36 grams, respectively.

Nitrogen loss through leaching was

¹ R. J. Borden is agronomist with Experiment Station, HSPA.

² In Hawaii. Planters' Rec. 40:39.

³ Project A 105—No. 161.2.

TABLE 1 ANALYSIS OF VARIANCE

Measurements	Variance (Mean Square)				L.S.D. (Least Significant Difference)		
	For Variety (1 d.f.)	For Nitrogen (3 d.f.)	For Interaction (3 d.f.)	For Error (40 d.f.)	For Varieties	For Nitrogen	For Interaction
Millable cane stalks only.							
Total green weight (grams) . . .	84840*	51873	57526	20718	84		
Per cent moisture	10.27**	34.64**	2.08	1.38	.7	1.0	
Total dry weight (grams)	21506**	28316**	10349*	2941	32	45	63
Brix of crusher juice	21.07**	4.84	.48	.83	.5	.8	
Pol of crusher juice	33.33**	15.63**	.76	1.10	.6	.9	
Purity of crusher juice	64.87**	90.28**	2.39	2.34	.9	1.3	
Yield per cent cane	25.96**	15.41**	.56	.87	.5	.8	
Pounds recoverable sugar . . . .	.1036**	.0547**	.0105	.0055	.04	.06	
Per cent N in juice . . . . .	.0248**	.0557**	.0031**	.0003	.010	.014	.020
Grams N in juice . . . . .	.0030	2.766**	.3258**	.0490		.18	.26
Per cent N in bagasse . . . . .	.1553**	.5515**	.0208**	.0011	.02	.03	.04
Grams N in bagasse	3.939**	8.650**	.4039**	.0805	.17	.23	.33
Grams N in stalks	4.160**	21.065**	.2338	.0860	.17	.24	
Tops and Trash.							
Total dry weight	131148**	3329	3406	2116	28		
Per cent N . . . . .	.0336**	.0421**	.0032*	.0009	.02	.03	.04
Grams N	5.644**	.8362**	.2193*	.0530	.13	.19	.27
Roots and Stubble.							
Total dry weight	66082**	4509**	2099**	459	12	18	25
Per cent N . . . . .	.0683*	.1954**	.0036	.0063	.05	.07	
Grams N	2.142**	2.312**	.1844**	.0273	.10	.14	.19
Entire Crop.							
Total dry weight	586534**	15218	26421*	7607	51		102
Total grams N	3.2396**	49.2306**	.3709	.1424	.22	.31	

**Significance at P = .01

*Significance at P = .05

prevented in the six replicated pots of each treatment by catching the leachate in drainage pans and returning it to the surface of the soil in the pot with the subsequent irrigation. After four months under glass, the pots were moved outside to cars that were moved under a glass roof as needed to prevent any loss of nutrients by leaching during heavy rains.

The crop was harvested at the age of 12 months. Its millable cane consisted almost entirely of primary stalks. Many

secondary stalks were harvested but as these had not made at least three internodes of millable cane, they were included with the trash. These secondaries were found especially in the higher nitrogen treatments of both varieties. None of the stalks had tasseled by October 22 when they were harvested, and examinations of the growing points indicated that very few stalks of either variety or nitrogen treatment had actually differentiated in their terminal growth characteristics.

ANALYSIS OF MILLABLE CANE STALKS

Complete harvest data together with nitrogen analyses of various fractions of the crop have been recorded and studied by analysis of variance (Table 1) to find

the significant effects of treatments. The more pertinent data are now summarized and ready for discussion. (Table 2).

TABLE 2

Variety	Nitrogen Level								Variety Averages	
	Low		Average		High		Excessive			
	GREEN WEIGHTS									
	gms.		gms.		gms.		gms.		gms.	
32-8560.....	2131		2164		2289		2119		2176	
37-1933.....	2244		1994		2098		2031		2092	
Nitrogen average..	2188		2079		2194		2075			
	MOISTURE									
	%		%		%		%		%	
32-8560.....	67.8		68.8		70.1		71.1		69.5	
37-1933.....	67.6		70.5		71.2		72.3		70.4	
Nitrogen average..	67.7		69.7		70.7		71.7			
	DRY WEIGHTS									
	gms.		gms.		gms.		gms.		gms.	
32-8560.....	685		674		684		612		664	
37-1933.....	727		589		605		565		621	
Nitrogen average..	706		631		644		589			
	JUICE EXTRACTION									
	Percentage of Millable Cane Weight									
	%		%		%		%		%	
32-8560.....	37.2		37.9		38.5		40.8		38.6	
37-1933.....	28.6		31.8		28.0		27.3		28.9	
Nitrogen average..	32.9		34.9		33.3		34.1			
	NITROGEN IN JUICE									
	%		%		%		%		%	
32-8560.....	.032		.064		.096		.188		.095	
37-1933.....	.043		.140		.165		.215		.141	
Nitrogen average..	.037		.102		.131		.202			
	BRIX AND POL OF CRUSHER JUICES									
	Brix	Pol	Brix	Pol	Brix	Pol	Brix	Pol	Brix	Pol
32-8560.....	22.8	21.3	22.3	20.4	21.8	19.7	21.4	18.6	22.1	20.0
37-1933.....	21.8	20.0	20.4	18.0	20.8	18.3	20.0	17.1	20.7	18.3
Nitrogen average..	22.3	20.6	21.3	19.2	21.3	19.0	20.7	17.8		
	CRUSHER JUICE PURITY									
	%		%		%		%		%	
32-8560.....	93.3		91.5		90.4		86.9		90.5	
37-1933.....	91.9		88.0		87.9		85.0		88.2	
Nitrogen average..	92.6		89.8		89.1		85.9			
	Y%C									
	%		%		%		%		%	
32-8560.....	16.5		15.7		15.1		13.9		15.3	
37-1933.....	15.4		13.6		13.8		12.5		13.8	
Nitrogen average..	16.0		14.6		14.4		13.2			
	RECOVERABLE SUGAR									
	lbs.		lbs.		lbs.		lbs.		lbs.	
32-8560.....	.78		.75		.76		.65		.73	
37-1933.....	.76		.60		.64		.56		.64	
Nitrogen average..	.77		.67		.70		.61			

In green weight of millable cane, 32-8560 averaged slightly more than 37-1933 because of its greater yield at both the average and high nitrogen levels. At the low nitrogen level there may be more total green weight from 37-1933, although the actual difference is short of statistical significance.

Differences between the four levels of nitrogen are not significant.

Millable stalk sections of 32-8560 had a slightly lower percentage of moisture than similar stalks of 37-1933.

The percentage moisture in both varieties increased as the nitrogen level was increased.

An interaction between varieties and nitrogen is indicated for the dry weights of stalks with millable cane. At the three higher levels of nitrogen, 32-8560 was ahead of 37-1933, but this position appears to be reversed at the low nitrogen level where 37-1933 with its low nitrogen application produced the largest amount of dry weight in millable stalk.

Increased nitrogen applications had no significant effect upon the millable cane dry weights from 32-8560 until an excessive amount was supplied, whereas with 37-1933 dry weight yields were decreased by much smaller amounts of nitrogen.

Although different amounts of nitrogen had no significant effects on juice extraction, there is a possible trend which indicates that increased nitrogen levels for 32-8560 produced cane from which more juice was obtained; this same trend was not found in 37-1933.

32-8560 has given a higher juice extraction in our small three-roller mill than 37-1933.

Both variety and nitrogen effects upon percentage of nitrogen in crusher juices are highly significant. Although the amount of difference between the two varieties at the low nitrogen level is not significant, it seems quite clear that the nitrogen concentration is higher in the juices from 37-1933, and that significant increases have resulted from each increase in nitrogen applied.

Brix and pol data show no evidence of an interaction between varieties and nitrogen. Both juice characteristics are significantly higher in 32-8560 than in 37-1933. And again increased nitrogen applications have resulted in a lowering of both the Brix and pol readings.

Superior juice purity from 32-8560, and deleterious effects from increased nitrogen applications for both varieties are quite definite.

The same relationships are shown for Y% C as for pol of crusher juices: 32-8560 leads 37-1933, and the increased nitrogen applications give a poorer quality, i.e., lower yields of recoverable sugar from each ton of cane milled.

Except at the low nitrogen level, 32-8560 has produced significantly more sugar than 37-1933 from our 12-month crop, but at the low amount of nitrogen, the two varieties have not produced significantly different amounts.

Sugar yields were not increased as the amounts of nitrogen for these 12-month crops were stepped-up. With 32-8560 a definite sugar loss occurred when the nitrogen application was excessive; with 37-1933 this loss in sugar yield occurred at a considerably lower nitrogen level.

NITROGEN RECOVERED IN STALKS ONLY

(a) Percentages and amounts of nitrogen recovered from crusher juices:

Variety	Nitrogen Level								Variety Averages	
	Low		Average		High		Excessive			
	%	gms.	%	gms.	%	gms.	%	gms.	%	gms.
32-8560.....	.032	.26	.064	.52	.096	.85	.188	1.64	.095	.82
37-1933.....	.043	.27	.140	.88	.165	.97	.215	1.21	.141	.83
Nitrogen average..	.037	.27	.102	.70	.131	.91	.202	1.42		

Some significant interactions were found from these measurements. Increased concentrations of nitrogen and actual quantities found in the juices were positively correlated with amounts applied; but variety comparisons were apparently influenced by the differences in nitrogen levels. For instance, the percentage N in juice of 32-8560, although not significantly different from 37-1933 at the low nitrogen level, was unquestionably lower at the other three levels.

Nitrogen recoveries (grams N) at both low and high levels were not significantly different, but whereas more nitrogen was found in the 37-1933 juice at the average level, this relationship was reversed for the two canes when the nitrogen applications were excessive.

(b) Percentages and amounts of N found in bagasse (after a 38.6 per cent extraction from 32-8560, and a 28.9 per cent extraction from 37-1933)—

Variety	Nitrogen Level								Variety Averages	
	Low		Average		High		Excessive			
	%	gms.	%	gms.	%	gms.	%	gms.	%	gms.
32-8560.....	.27	1.37	.43	2.13	.51	2.50	.70	2.97	.48	2.24
37-1933.....	.27	1.58	.54	2.46	.68	3.25	.87	3.96	.59	2.81
Nitrogen average..	.27	1.48	.49	2.29	.59	2.88	.78	3.47		

In the bagasse as in the juice, both the percentage N and the grams of N were increased as nitrogen levels were raised.

Variety differences were not proved at the low N level, but both percentages and amounts of N were significantly higher in the 37-1933 bagasse from the

three higher levels.

(c). Total grams nitrogen in stalks:

Combining the data from (a) and (b) we have the following summary of the total grams of nitrogen recovered in the millable stalks of these two varieties:

Variety	Nitrogen Level				Variety Averages
	Low	Average	High	Excessive	
	gms.	gms.	gms.	gms.	gms.
32-8560.....	1.63	2.65	3.34	4.61	3.06
37-1933.....	1.85	3.34	4.22	5.17	3.65
Nitrogen average..	1.74	3.00	3.78	4.89	

Actual amounts of nitrogen found in the stalks of 37-1933 were definitely higher than in 32-8560; and nitrogen

recoveries were positively correlated with the amounts applied.

ANALYSIS OF TOPS AND TRASH

Green tops at harvest were dried and added to all trash that had been carefully collected and saved while the crop was growing. All shoots that had not

made at least three visible internodes at 12 months were also included with this trash; such shoots were noted to be more numerous in 32-8560 than in 37-1933.

Table 3

Variety	Nitrogen Level								Variety Averages	
	Low		Average		High		Excessive			
	DRY WEIGHTS									
	gms.		gms.		gms.		* gms.		gms.	
32-8560.....	406		424		439		426		424	
37-1933.....	332		274*		331		341		319	
Nitrogen average..	369		349		385		383			
	NITROGEN									
	%	gms.	%	gms.	%	gms.	%	gms.	%	gms.
32-8560.....	.39	1.60	.49	2.10	.52	2.26	.56	2.37	.49	2.08
37-1933.....	.39	1.27	.41	1.14	.44	1.47	.51	1.70	.44	1.40
Nitrogen average..	.39	1.44	.45	1.62	.48	1.86	.53	2.03		

*Three of the six replicates in this treatment had stalks with weak, spindly tops at harvest; reason unknown.

Variety differences were significant with 32-8560 producing the greater amounts of tops and trash. Differences in nitrogen levels apparently did not affect these dry weights. (Table 3)

Nitrogen effects were significant and both varieties showed higher concentrations from the increased applications. Variety differences were found to favor 32-8560 at the three higher nitrogen

levels but not at the low level.

Recovery of nitrogen in the tops and trash of 32-8560 was almost 50 per cent more than in 37-1933. (Table 3)

Except for the unexplained low yield of tops in 37-1933 grown at the average nitrogen level, increased applications of nitrogen were followed by higher nitrogen recoveries in these tops and trash collections.

ANALYSIS OF ROOTS AND STUBBLE

Cane stubble left in the soil after cutting the stalks at ground level, and all roots that could be collected by screening the soil and by quick flotation were combined for a study of amounts and nitrogen content of this "below ground" crop.

Variety differences are quite clear, and 32-8560 has left a considerably greater stubble and root mass underground.

Nitrogen effects for the two varieties are somewhat different. With 32-8560, these dry-weight differences between the four nitrogen levels are such as could be expected by chance alone. In the case of 37-1933, however, an increased stubble plus root mass has resulted from the increased nitrogen applications. (Table 4)

Table 4

Variety	Nitrogen Level								Variety Averages	
	Low		Average		High		Excessive			
	DRY WEIGHTS									
	gms.		gms.		gms.		gms.		gms.	
32-8560.....	243		265		256		266		257	
37-1933.....	154		163		192		224		183	
Nitrogen average..	199		214		224		245			
	NITROGEN									
	%	gms.	%	gms.	%	gms.	%	gms.	%	gms.
32-8560.....	.61	1.49	.79	2.08	.85	2.17	.90	2.40	.79	2.03
37-1933.....	.71	1.09	.81	1.33	.93	1.77	1.01	2.26	.86	1.61
Nitrogen average..	.66	1.29	.80	1.70	.89	1.97	.96	2.33		

No interaction was found from these measurements. Hence, it is quite clear that 37-1933 roots and stubble contained the higher percentage of nitrogen, and that an increased nitrogen concentration of roots and stubble has followed the increased nitrogen applications for both varieties. (Table 4)

Although the percentage of nitrogen

in roots and stubble from 37-1933 was higher, actual amount of nitrogen was significantly greater from the roots and stubble of 32-8560 because of their larger amount of dry weight.

Positive relationships between nitrogen applied and the amounts of nitrogen recovered in these below ground parts of both varieties were found.

ANALYSIS OF ENTIRE CROP

A summary of the foregoing figures studied separately from the millable cane crusher juices and bagasse; from tops and trash, and from roots and stubble, allows the following comparisons to be made on the entire crops grown.

A statistical analysis of the data

from which this summary was made, shows a highly significant gain in the total dry weight for 32-8560 over 37-1933.

The effect from the nitrogen applications on the two varieties was not quite the same, e.g., yields of total dry weight

TOTAL DRY WEIGHT OF ENTIRE CROP

Variety	Nitrogen Level				Variety Averages
	Low	Average	High	Excessive	
	gms.	gms.	gms.	gms.	gms.
32-8560.....	1335	1363	1379	1304	1345
37-1933.....	1213	1026	1127	1130	1124
Nitrogen average..	1274	1194	1253	1217	

from the 32-8560 crop were not significantly different at any of the four nitrogen levels. The poorer yield from the crop of 37-1933 grown at the average nitrogen level has not been satisfactorily accounted for as a treatment effect. Higher yield from 37-1933 at the low nitrogen level is suggestive⁴ that the increased nitrogen applications have not benefited this 12-month crop.

NITROGEN RECOVERY Recovery of 7.17 grams of nitrogen in the total amount of plant material produced by 32-8560 was significantly greater than 6.65 grams from 37-1933. Amounts recovered in both varieties from the increased nitrogen levels showed a direct relationship to amounts available, i.e., an average of 4.47, 6.31, 7.62, and 9.25 grams of nitrogen, respectively.

The percentage recoveries from the total available nitrogen supplies⁵ by both varieties were greatest at their low nitrogen levels, and were progressively less as these nitrogen totals were increased. Nitrogen recoveries by 37-1933, especial-

ly at the two lower levels, were considerably below the excellent recoveries in 32-8560 (**Figure 1**).

Soil analyses after harvest showed differences in available nitrogen left behind in the soil which are far too small to account for the differences in nitrogen recoveries in the crops harvested.

Distribution of total nitrogen found in the crops of both varieties is also shown in **Figure 1**. In both varieties the greater amounts of total nitrogen recovered, from all four levels of nitrogen, were found in the millable stalks. And as the graph shows, the proportions were considerably higher in the 37-1933 crops.

At similar nitrogen levels, 32-8560 carried more nitrogen than 37-1933 in its tops and trash, and also in its roots and stubbles. Amounts found in its tops and trash were only slightly more than those in its roots and stubble. With 37-1933, however, except at the low nitrogen level, roots and stubble carried a greater proportion of total nitrogen than did its tops and trash.

DISTRIBUTION OF DRY WEIGHT MATERIAL
Percentage of Total Dry Weight

Found as	Variety		Nitrogen Level				Approx. Averages
	32-8560	37-1933	Low	Average	High	Excessive	
Millable stalks.....	49	55	55	53	51	49	52
Tops and trash.....	31	29	29	29	31	30	30
Roots and stubble.....	20	16	16	18	18	20	18

37-1933 had more than half of its total dry weight in its stalks and consequently less in its non-millable components.

Increased applications of nitrogen ap-

pear to have given a slightly lower proportion of millable cane and correspondingly increased amounts of non-millable cane.

4 A difference of 102 grams is needed for the least significant difference between the four levels of nitrogen for either variety.
 5 Includes .36 gram available N in soil at potting, plus amounts added in fertilizer.

NITROGEN RECOVERIES

(a) In Total Dry Weight
(b) In Millable Stalks

(c) In Tops and Trash
(d) In Roots and Stubble

By 32-8560

By 37-1933

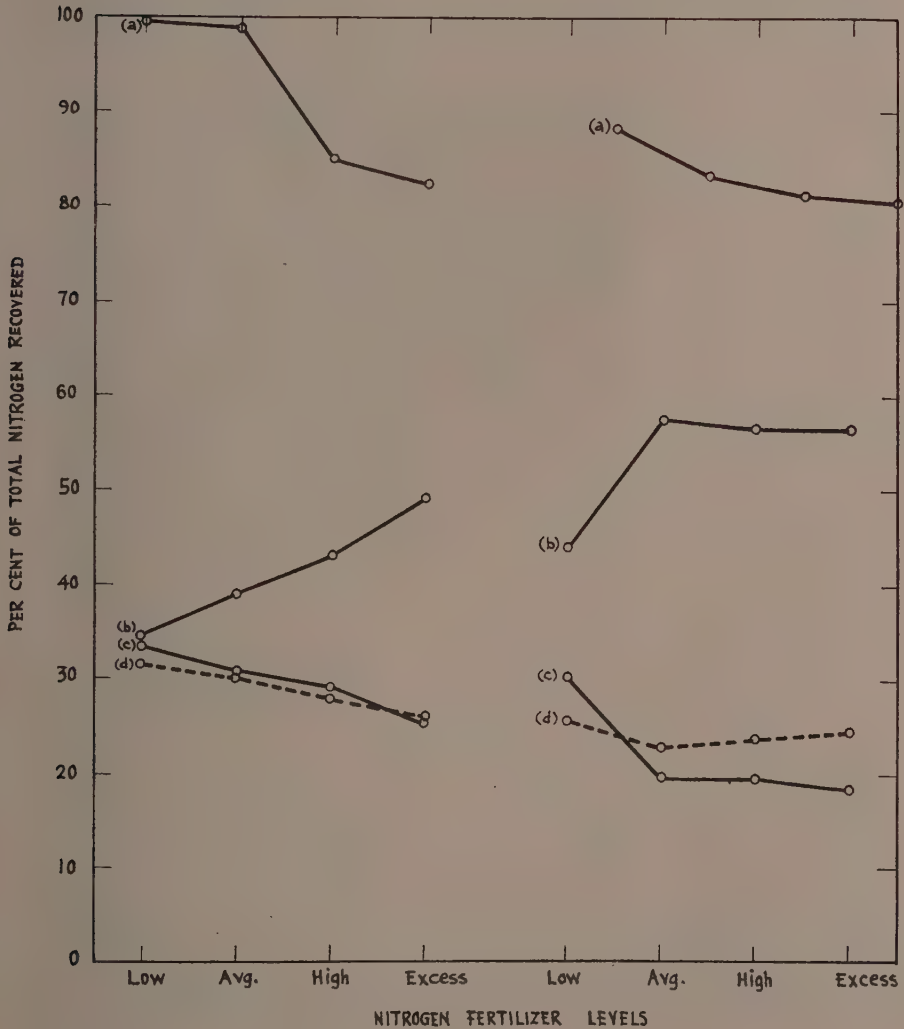


Figure 1.

Comparative Ratios of Total Dry Weights

Ratio of	Variety		Nitrogen Level				Approx. Averages
	32-8560	37-1933	Low	Average	High	Excessive	
1—Roots and stubble to tops, trash, and stalks.....	.24	.19	.18	.22	.22	.25	.22
2—Roots and stubble to tops and trash.....	.61	.57	.53	.61	.58	.64	.59
3—Roots and stubble to stalks.....	.39	.30	.28	.34	.35	.41	.34
4—Tops and trash to stalks....	.64	.51	.52	.55	.60	.65	.57
5—Tops, trash, roots and stubble to stalks.....	1.03	.81	.80	.89	.95	1.06	.92

From this tabulation of the principal ratios of dry weights in the crop segregation, there are several points of interest:-

- 37-1933 had a smaller proportion of its total dry weight than 32-8560 in the so-called "non-millable" components of its crop than in its millable stalks; this was the effect from its lower ratios of tops and trash to stalks, and of roots and stubble to stalks.
- Increased amounts of nitrogen gave corresponding increases in the ratios of underground parts, and also of trash to the stalks that carry the sugar.
- For each 100 tons of millable stalks

harvested with an average moisture content of 70 per cent, we should find 30 tons of dry matter. From our ratios then, we can calculate that in the production of these 30 tons in the stalks, we have also produced an additional 27 tons of dry matter—17 tons in the trash and tops and 10 tons in the roots and stubble. These 10 tons of roots and stubble (dry weight) would be equivalent to somewhere near 20 tons of green weight of organic material which is left behind *in the soil* when 100-ton crops of cane are harvested. This is the principal source of the material that enables us to maintain and even build up the organic matter content in our continuously cropped soils.

SUMMARY

This is a study of the way in which crops of 32-8560 and 37-1933 are influenced by differences in their nitrogen fertilization. Only a few of the measurements that were made showed that the nitrogen had not always influenced these two canes in the same way, and the more significant interactions point to the probability that they have differed chiefly in their use of nitrogen for the production of total dry weight of millable stalks, for dry weight of roots and stubble, and for total dry weight of their entire crop. In other respects, there has been quite good agreement in the direction of their response to the different nitrogen levels, although the degree or the actual amounts of this response has been different in many instances.

Because most of the nitrogen effects have been shown to be more significant than their interaction with varieties, we find that both varieties have responded to our increased amounts of nitrogen with corresponding—

- Increases in the percentages of moisture and nitrogen in their millable stalks.
- Decreased in Brix, pol, purity, and yield per cent cane in their crusher juices.
- Lower amounts of recoverable sugar.
- Increases in percentages and amounts of nitrogen in crusher juices and bagasse.
- Increases in percentages and amounts of nitrogen in trash and tops, and also in roots and stubble.
- Increases in total recoveries of nitrogen from entire crop, but decreases in percentage recoveries from total available nitrogen supply.
- Increases in available nitrogen left behind in the soil at harvest.
- And increases in the ratios of the non-millable stalk components of the total dry weight that was produced by the larger nitrogen applications.

Some measurements in the variety comparisons show an influence from the different nitrogen applications. For instance—

- Although 32-8560 produced more dry weight of millable stalks and also of recoverable sugar at the three higher levels of nitrogen, this superiority was not found at the low nitrogen level.
- Whereas the percentage and amount of nitrogen found in the crusher juice and bagasse of the two varieties was not significantly different when the level of nitrogen was low, 37-1933 had more nitrogen in its juice than 32-8560 at the average nitrogen level but less than 32-8560 at the excessive level.
- Differences in percentage N in tops and trash at the low level were similar but at the three higher levels, they favored 32-8560.

In other respects, regardless of the nitrogen levels used in this test, variety comparisons show that 32-8560 had more green weight of stalks with a lower percentage moisture, a higher juice extraction, higher Brix, pol, purity, and yield per cent cane, a lower amount of nitrogen recovered in its millable stalks, more tops and trash, and more grams of nitrogen in the tops and trash, more roots and stubble, and more nitrogen in this below ground part of the crop that was left in the soil, although the percentage N in the 32-8560 roots and stubble was lower, a higher yield of total dry weight and more N recovered in the entire crop grown, higher recoveries of available nitrogen supplies, and higher proportions of non-millable roots, stubble, tops, and trash to the millable cane stalks.

In the final analysis, recoverable sugar yields tell us that the two varieties were equally efficient at our low nitrogen level and that sugar yields for this 12-month crop were not increased by giving more nitrogen, but at the higher amounts of nitrogen, 32-8560 was a better producer than 37-1933 under the conditions of this experiment. Thus from this study there is little evidence to warrant an opinion that 37-1933 needs more nitrogen than 32-8560.

Horizontal Distribution of Exchangeable Potassium in Soils of the Island of Hawaii

By A. S. Ayres, H. H. Hagihara, and C. K. Fujimoto¹

SUMMARY

As a continuation of our study of distribution of exchangeable potassium in soils of Hawaii, we investigated profiles of 24 soils of the island of Hawaii where rainfall ranged from 40 to 240 inches.

Our study showed that—

- The supply of potassium in the surface layer of soil is often a poor index of the total amount of potassium available to a relatively deep-rooted crop such as sugar cane.
- Under conditions of moderate rainfall, distribution patterns for potassium in the soil profile generally followed those established in a previous study for the subhumid, irrigated sugar cane soils of Oahu. By this we mean that potassium decreased sharply through the first 12 to 24 inches and after that it either continued to drop in value, stayed constant, or rose in value.
- At more than 125 inches of rain per annum, the surface 0 to six-inch horizon, although as a rule highest in potassium, differed from corresponding lower horizons much less in this respect than was the case in the dry to sub-humid regions. Irregularity of distribution marked the potassium content of the profiles of the humid region soils.
- In the humid region soils we found that levels of potassium are generally low, often averaging less than 0.20 milliequivalent per 100 grams. We also discovered equally low levels of potassium in a few of the subhumid region profiles, but in a few of the less humid Kohala and Kau soils exceedingly high amounts of potassium were found.

For a relatively deep-rooted crop such as sugar cane, the supply of available potassium is not ordinarily restricted to the layer of soil commonly examined in routine tests for this nutrient. In soils that are well aerated and of suitable consistency, cane roots have been observed at considerable depths. It seems within reason

¹ A. S. Ayres is associate chemist and H. H. Hagihara is analyst, Experiment Station, HSPA, and C. K. Fujimoto is junior chemist, Hawaii Agricultural Experiment Station.

to conclude that in such soils, potassium, at distances as great as three and even four feet from the surface, may aid substantially in meeting the potassium need of the crop.

In 1944 two of us (3) at the Hawaii Agricultural Experiment Station studied the distribution of exchangeable potassium to depths ranging from two to seven feet in 31 profiles of Oahu sugar cane and virgin soils. In this paper we are reporting on an extension of the study to the very different soils of the island of Hawaii—soils on which sugar cane is grown principally without irrigation.

The brief literature on the subject of the distribution of exchangeable potassium in soil profiles was reviewed in the earlier paper and will not be repeated here. Results obtained in that study revealed in all of the profiles examined a tendency for the level of potassium to decrease sharply with depth to a point one to two feet below the surface. Below this point, the pattern was no longer uniform. In some profiles the level of potassium continued to decrease, although more gradually, to the bottom of the section examined; in others, there was no decrease beyond the two-foot level, and in still others, potassium increased in concentration with greater depth, in some cases being higher at four feet than in the surface six inches.

SOIL DESCRIPTION

Soils examined for this study lie on the slopes of Mauna Kea, Mauna Loa, and the Kohala mountains at elevations ranging from near sea level to approximately 3000 feet, with rainfalls varying from roughly 40 to 240 inches per annum. Those soils in the subhumid regions are irrigated. Most of the soils, many of which are highly weathered, are derived from volcanic ash and range in depth from very shallow phases to deep or normal phases. These comprise the soils of the Humic Latosol, Hydrol Humic Latosol, and Reddish Prairie soil groups. They include also one of the Lithosols—a rockland type with a very thin covering of weathered volcanic ash. Remainder of the soils studied comprise the

Kohala family of the Low Humic Latosol group.

All the soils are acid throughout the profile, with the exception of the Prairie soils which are acid only in the surface layer. Degree of leaching of the Hydrol Humic Latosols is extreme in regions of high rainfall, the soils often containing only a few milliequivalents of exchangeable bases per 100 grams of soil. Cation exchange capacities in these soils are largely associated with the organic fraction of the soil and range from moderate to high values. The soils are pervious and well drained, except when severely compacted by heavy harvesting equipment.

SAMPLING METHOD

The sampling operation was carried out in the following manner:

A trench five to six feet long and two feet deep was dug midway between two adjacent rows of cane. The soil was then sampled to the indicated depth by slicing a thin layer of soil from one face of the trench in six-inch increments. Sam-

pling was then continued to the depth of four feet by a series of borings in the bottom of the trench. Here also samples were taken at six-inch intervals.

Distribution of potassium in the profile of sugar cane soils is obviously dependent upon location of the profile in the field. Thus, successive increments

taken as described will not in all probability contain amounts of potassium identical with corresponding increments taken, for example, in the cane row itself. This must be the case since the roots are more concentrated in the vicinity of the row and, furthermore, it is in or near the row that potassium fertilizer is applied. Because it was felt that the profile distribution of potassium between the rows would be more stable than in

the row itself, and also for the sake of expediency in sampling, the designated location was chosen.

In a few instances shallow soils were encountered. In such cases, depth of sampling was determined by depth of the soil. The depths to which soils were sampled are indicated in **Table 1**. A total of 24 profiles, including two of forest soils, were studied.

METHODS OF ANALYSIS

Exchangeable potassium was extracted with normal ammonium acetate adjusted to pH 7.0. Ammonium and organic matter were eliminated from the extracts by the method of Peech (5) and potassium

determined by the cobaltinitrite procedure of Volk (6) for small amounts of exchangeable potassium in soils.

pH values were measured by means of the glass electrode.

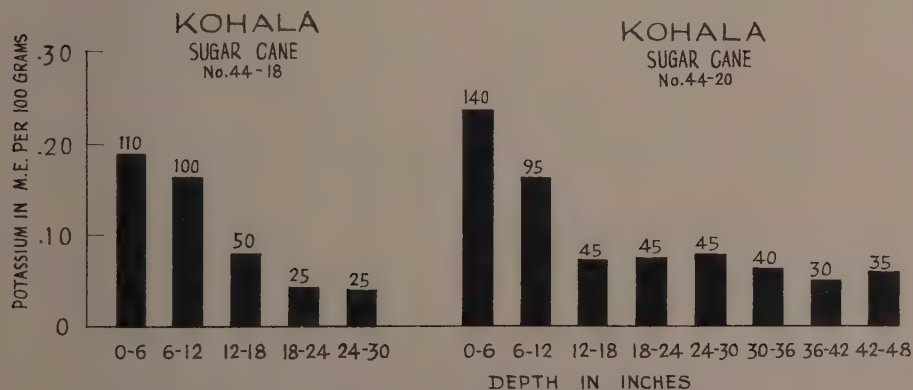
EXPERIMENTAL RESULTS

Levels of exchangeable potassium in the profiles, together with corresponding pH values, are shown in **Table 1**. Data for potassium are also indicated in a series of bar-diagrams in which successive bars represent successive six-inch horizons of the profile. Levels of potassium are indicated in two ways:

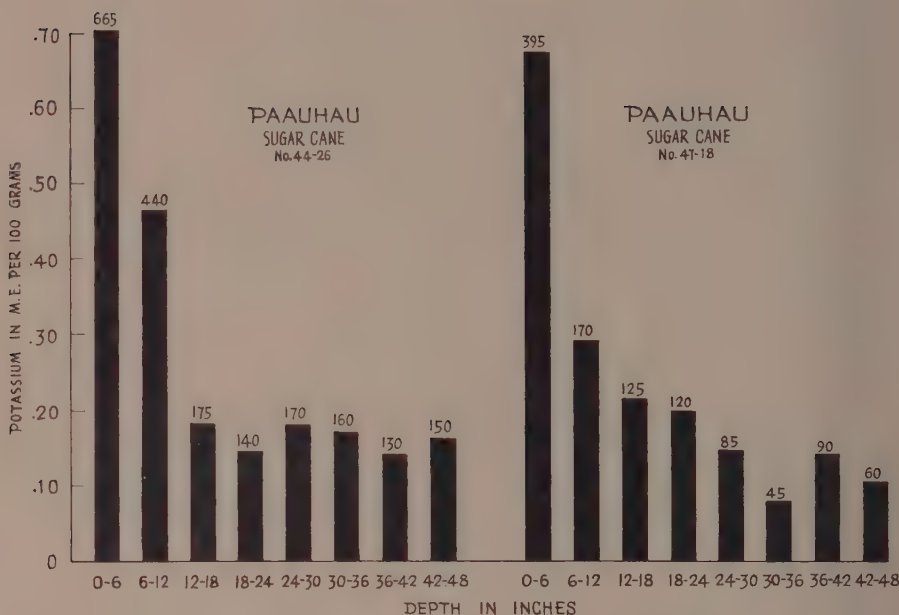
- In the conventional terms of milliequivalents per 100 grams of oven-dry soil, as shown by the heights of the bars,

- And in the more familiar terms of pounds K_2O per acre six inches of oven-dry soil, based on an approximate average value of 2,500,000 pounds of oven-dry soil per acre-foot of Hawaiian soils as a whole.

These latter values, which are to be found immediately above the bars, are grossly in error for low volume-weight ash-derived soils, and evaluation on the basis of milliequivalents of potassium per 100 grams of soil is much to be pre-



Figures 1 and 2. Figure 1 on the left and Figure 2 on the right.



Figures 3 and 4. Figure 3 on the left, Figure 4 on the right.

ferred on such soils. Owing to abnormally large quantities of potassium, a reduced scale was used in the cases of **Figures 7 and 23**.

About a third of the profiles examined (**Figures 1 to 8**) resemble those of the Oahu soils described earlier in this paper. The soils having these patterns are, with a single exception (**Figure 8**), in the less humid regions of the island. In the humid region soils, as well as in the drier Kohala soils (**Figures 9-24**), distribution of potassium was irregular and in most instances there was little or no discernable pattern, except that potassium was generally at its highest point in the 0 to six-inch horizon. The difference in potassium levels between the surface layer and the lower horizons in these soils is not, however, as great as in the drier areas. This effect of rainfall on the horizontal distribution of potassium was previously observed by Borden (4) in biological studies and subsequently by Ayres (1) in chemical studies of the

humid region soils of the island of Hawaii.

With few exceptions levels of exchangeable potassium were very low in profiles of the high-rainfall soils. At more than 125 inches of rain there was scarcely a profile that contained, on the average, as much as 0.20 milliequivalent of potassium per 100 grams of soil. In a few instances the average value was as low as 0.10 milliequivalent.

Three soils of the less humid areas deserve special mention because of the unusually high levels of potassium present in at least portions of the profile. One of these (**Figure 6**) is in the Upolu section of Kohala. In this profile levels of potassium in the 0-6, 6-12, and 12-18 inch horizons of this soil are 1.85, 1.72, and 1.12 milliequivalents per 100 grams, respectively. Between 18 and 24 inches, however, there is an abrupt drop, and below this point potassium is extremely low, not exceeding 0.10 milliequivalent.

Still greater amounts of potassium

were found in a profile (**Figure 23**) from the Puakea section of the same plantation. This soil contained, in the top four six-inch increments, amounts of potassium ranging from 1.26 to as much as 4.51 milliequivalents per 100 grams. In contrast, the next three succeeding increments contained less than 0.10 milliequivalent. In the eighth increment (42-48 inches) the potassium level rose abruptly to 1.23 milliequivalents.

Highest levels of potassium we have ever encountered were observed in a profile (**Figure 7**) from Naalehu. Values for the various six-inch increments ranged from 2.63 to 6.41 milliequivalents per 100 grams. Unlike the two profiles just discussed, this profile contained no low values. Subsequent analysis of a composite sample² of the first foot of soil of the field as a whole gave a value of 3.40 milliequivalents per 100 grams—a value lower than the corresponding one ob-

tained for the profile, yet unusually high.

Comparison of the profile of an extreme mauka sugar cane soil at Onomea (**Figure 16**) with one of a forested soil (**Figure 15**) in the same vicinity but at a slightly higher elevation and about the same rainfall reveals no pronounced differences so far as distribution of potassium is concerned. For the profile as a whole, potassium is slightly higher in the cultivated soil. A similar comparison at Pepeekeo, but one in which differences in elevation and rainfall are greater, may be seen in **Figures 14 and 8** for the sugar cane and forested soil, respectively. In this instance, cultivated soil is noticeably higher in potassium than is forested soil.

All the soils are acid throughout the profile, except No. 47-30 (**Figure 7**) at Naalehu, which is neutral below the 18-inch level.

DISCUSSION

Distribution of exchangeable potassium in the profile of a soil supporting vegetation is largely the result of two things.

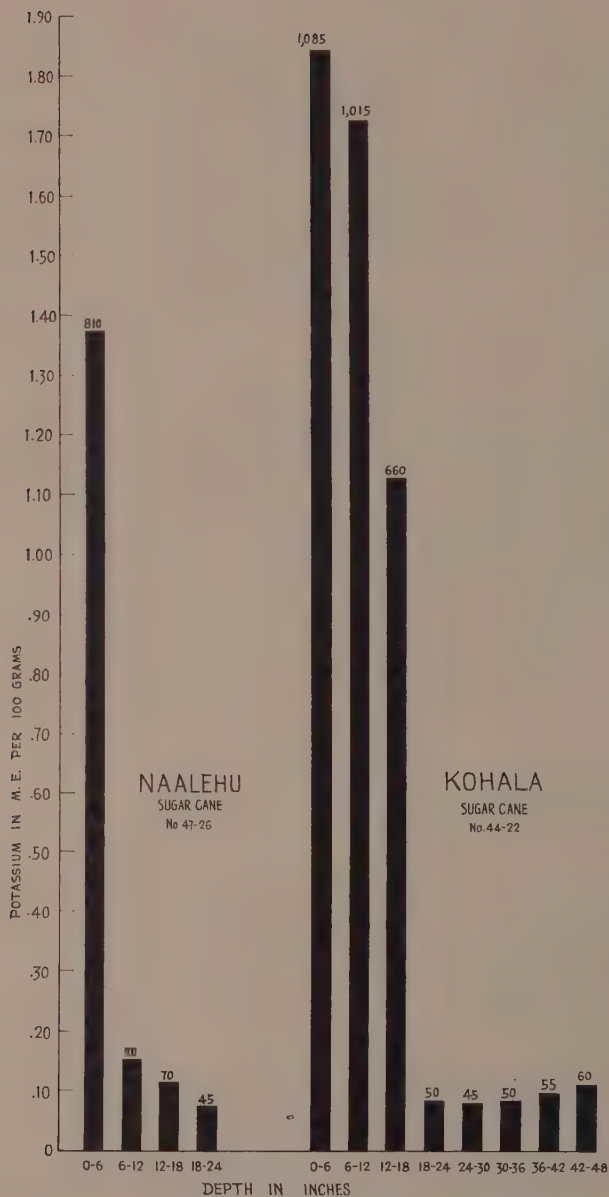
One of these is the downward movement of water that leaches the upper portion of the profile more severely than the lower portion, thus tending to establish a potassium gradient that increases with depth. Examples of this effect of leaching may be found in a report on a study of Hawaiian soils by Ayres (2).

The other factor is the upward movement of potassium through the roots to the aerial portions of the plant where, either through death of the plant or sloughing of dead parts, potassium is deposited on the soil surface. In cropped soils, where at least part of the potassium is removed from the field in produce and hence is prevented from reaching the

soil surface, restoration is frequently made in the form of fertilizer. Effect of these depositions on the surface is to promote a potassium gradient in the soil that decreases with depth through that portion of the profile in which roots are active. Vertical distribution of potassium observed in the field is thus largely the composite result of these two opposing factors.

It is to be expected, on the basis of the above discussion, that pronounced decreases in the level of potassium from the surface downward through the first one to two feet of soil will generally be confined to the dry to subhumid areas. Correspondingly, it would be anticipated that where rainfall is heavy and leaching intense, differences between levels of potassium in the surface layer and in the deeper layers would be moderate. This

² Furnished through the courtesy of the plantation.



Figures 5 and 6. Figure 5 on the left and Figure 6 on the right.

concept appears to be borne out by results of the present study.

Distribution patterns showing but little differentiation between surface and lower horizons may also conceivably develop in regions of low rainfall either as

a result of nearly complete removal of aerial parts of the plants as, for example, in Napier grass culture [c.f. paper by Ayres and Fujimoto (3)], or through lack of potassium fertilization.

The exceptionally high levels of potas-

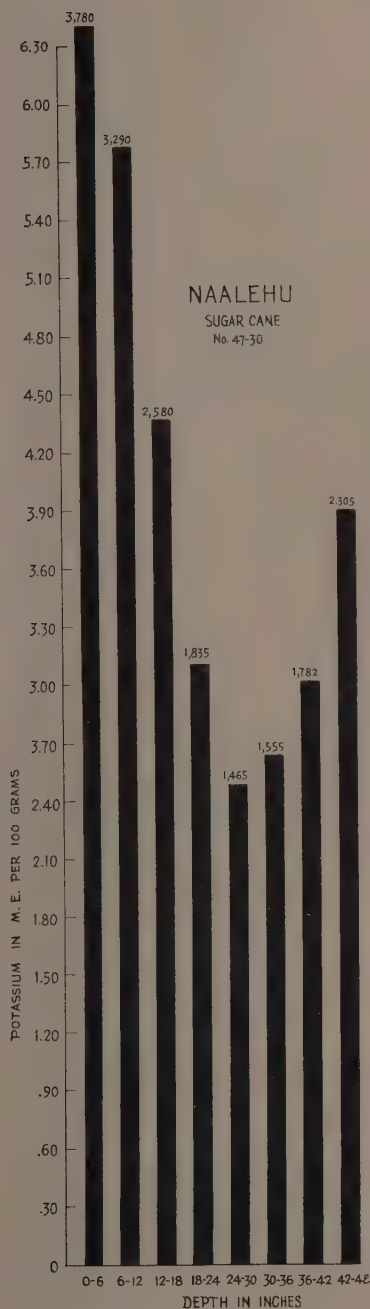


Figure 7.

sium present in profile 44-30, Naalehu, are apparently attributable to the fact that this soil is a member of the Reddish Prairie soil group. Soils of this group are derived from relatively young volcanic ash and, owing to this fact and to the moderate rainfall of the region, are but slightly leached. This condition is reflected also in the comparatively high pH values in profile 47-30, Naalehu (Figure 7).

The unusually high levels of potassium in the upper portion of profile 44-21 (Figure 23), Puakea, Kohala, are also associated with relatively young volcanic ash, although soil of the region as a whole is a normally-weathered soil of the Low Humic Latosol group. Source of the ash in this case was a small cinder cone a short distance above where the profile was taken.

Reason for the high levels of potassium in the upper portion of profile 44-22 (Figure 6), Upolu, Kohala, is not apparent.

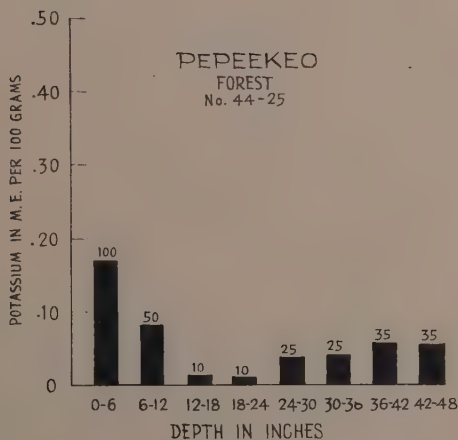
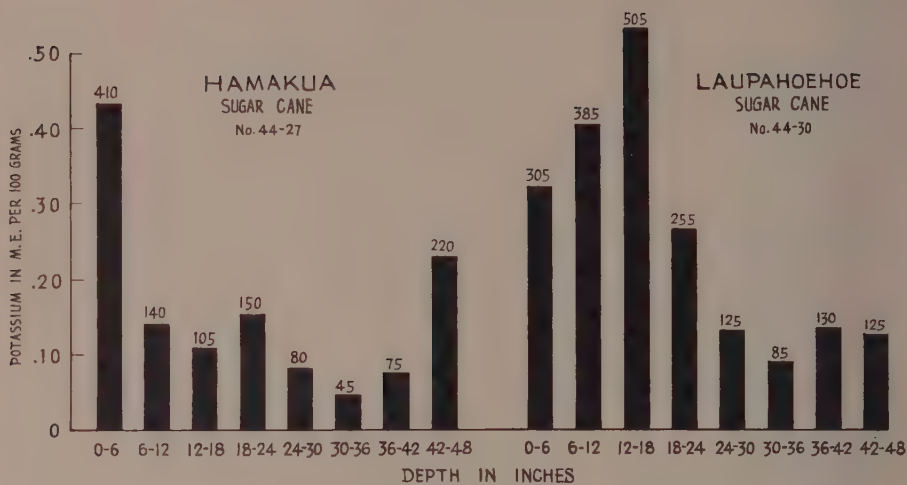
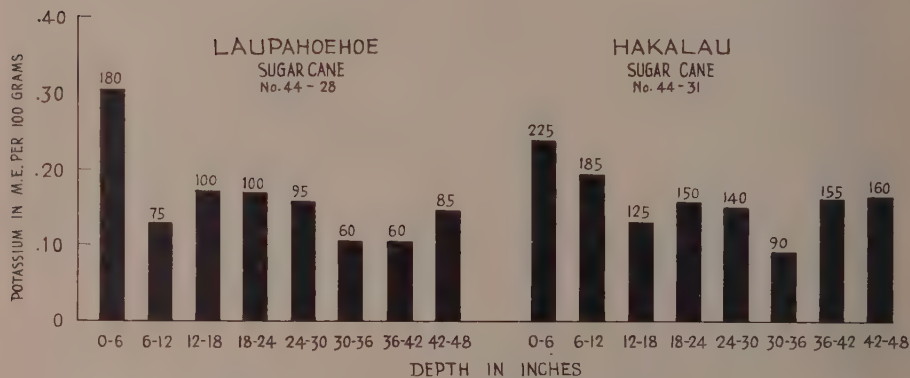


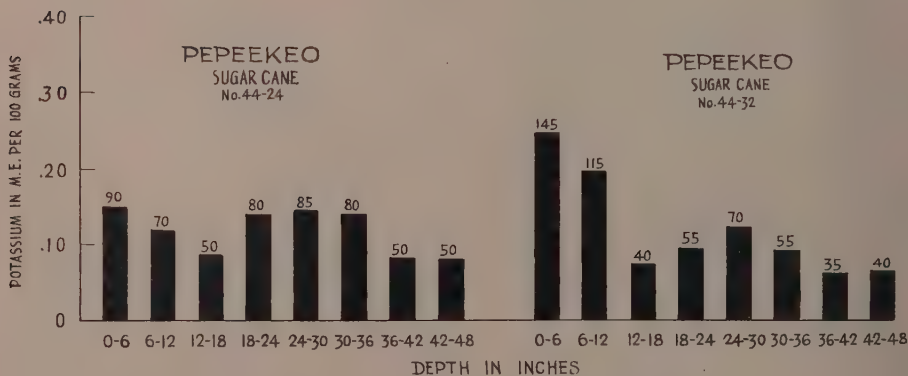
Figure 8.



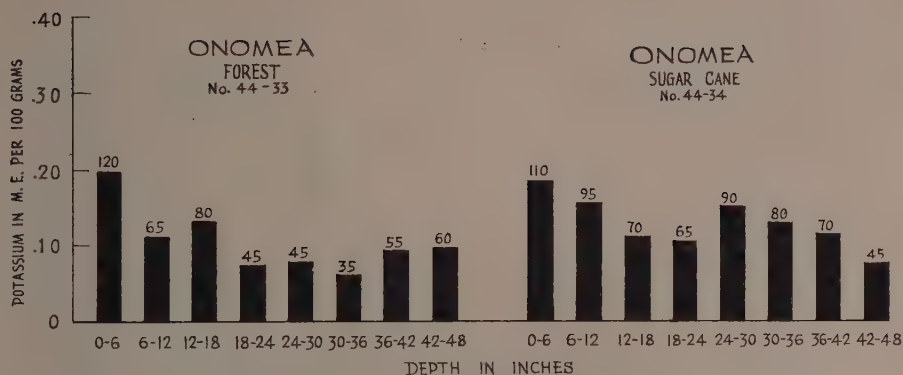
Figures 9 and 10. Figure 9 on left, Figure 10 on right.



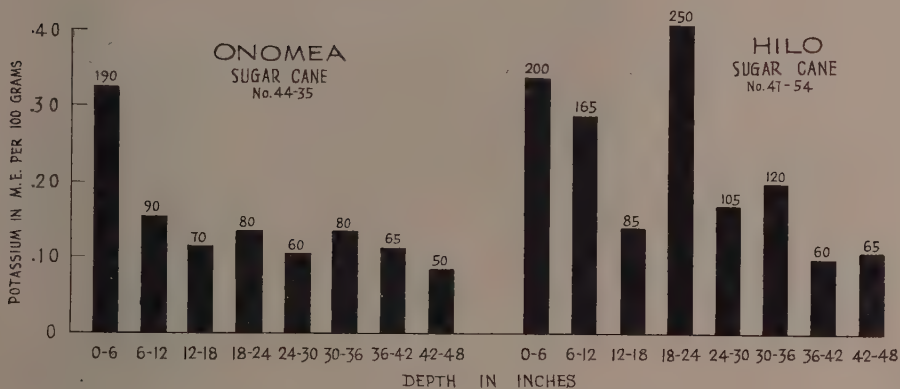
Figures 11 and 12. Figure 11 on left, Figure 12 on right.



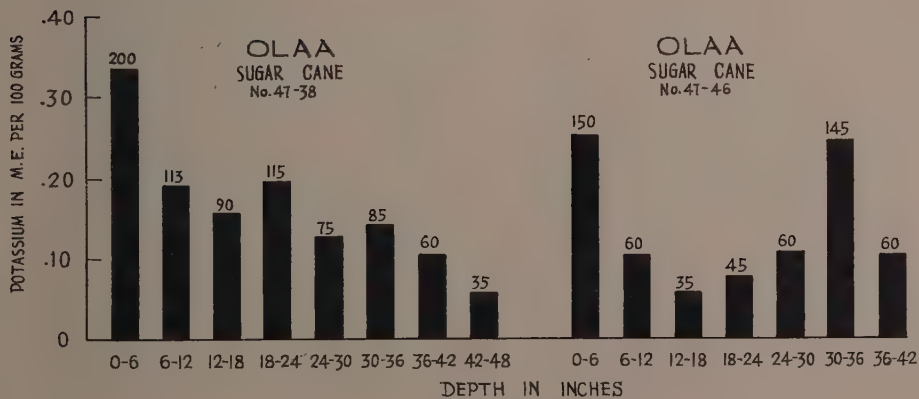
Figures 13 and 14. Figure 13 on left, Figure 14 on right.



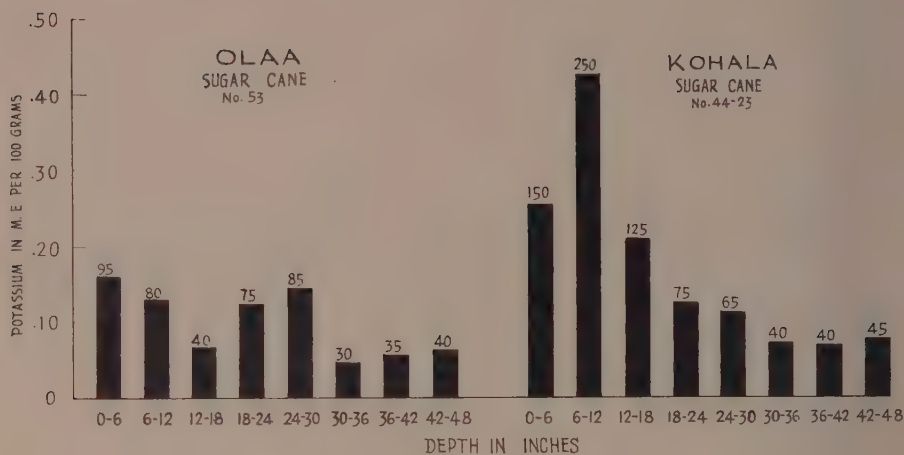
Figures 15 and 16. Figure 15 on left, Figure 16 on right.



Figures 17 and 18. Figure 17 on left, Figure 18 on right.



Figures 19 and 20. Left, Figure 19, right, Figure 20.



Figures 21 and 22. Left, Figure 21, right, Figure 22.

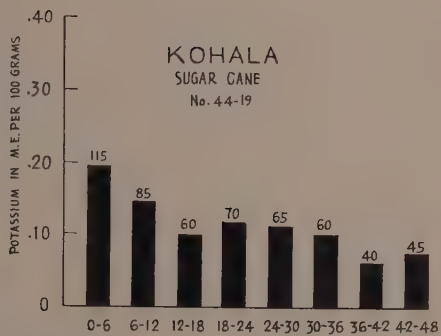
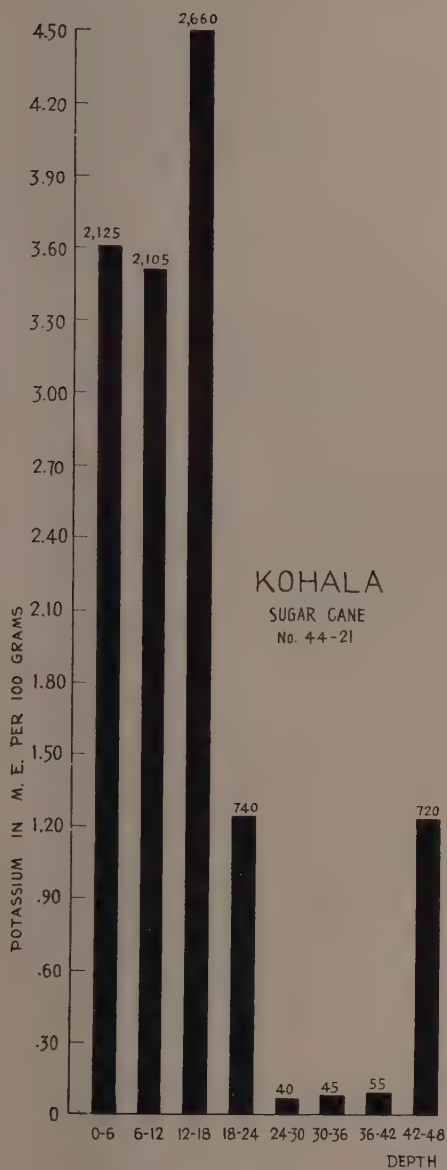
Profile Studies in Relation to Routine Soil Sampling

It appears from the data presented that the level of potassium in the surface layer of soil is frequently a poor indication of the total quantity of potassium to which the cane crop has access. Findings of the study

might, therefore, be profitably kept in view when evaluating the results of routine chemical analyses based upon the potassium content of the surface layer.

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Figures 23 and 24. Left, Figure 23, right, Figure 24.

TABLE 1
DESCRIPTION OF SOILS, EXCHANGEABLE POTASSIUM, AND pH VALUES
(Asterisk indicates irrigated soils)

Lab. No.	Soil Group	Soil Family	Symbol	Plantation	Elevation (feet)	Mean Annual Rain- fall (inches)	Vegeta- tion	Depth (inches)	Potas- sium (m.e./ 100 gm.)	pH
44-26a	Humic Latosols	Paauhau, normal phases	A4	Paauhau	400	65*	Sugar cane	0-6	70	5.9
26b								6-12	47	6.0
26c								12-18	19	5.9
26d								18-24	15	6.1
26e								24-30	18	6.3
26f								30-36	17	6.3
26g								36-42	14	6.4
26h								42-48	16	6.5
22-27a	Humic Latosols	Ookala, normal phases	A5	Hamakua	1250	120	Sugar cane	0-6	43	5.3
27b								6-12	15	5.2
27c								12-18	11	5.4
27d								18-24	16	5.4
27e								24-30	08	5.4
27f								30-36	05	5.5
27g								36-42	08	5.5
27h								42-48	23	5.7
44-30a	Humic Latosols	Ookala, normal phases	A5	Laupahoehoe	600	125	Sugar cane	0-6	32	4.7
30b								6-12	41	4.6
30c								12-18	53	4.7
30d								18-24	27	5.4
30e								24-30	13	5.5
30f								30-36	09	5.6
30g								36-42	14	5.4
30h								42-48	13	5.3
44-31a	Humic Latosols	Ookala, normal phases	A5	Hakalau	300	145	Sugar cane	0-6	24	5.1
31b								6-12	20	5.3
31c								12-18	13	5.4
31d								18-24	16	5.4
31e								24-30	15	5.4
31f								30-36	09	5.4
31g								36-42	16	5.5
31h								42-48	17	5.5

TABLE 1 (Continued)

Lab. No.	Soil Group	Soil Family	Symbol	Plantation	Eleva- tion (feet)	Mean Annual Rain- fall (inches)	Vegeta- tion	Depth (inches)	Potas- sium (m.e./ 100 gm.)	pH
44-24a	Hydrol Humic Latosols	Hilo, normal phases	K6	Pepekeo	600	150	Sugar cane	0-6	.15	4.8
24b								6-12	.12	4.9
24c								12-18	.09	4.9
24d								18-24	.14	5.0
24e								24-30	.15	5.2
24f								30-36	.14	5.5
24g								36-42	.08	5.6
24h								42-48	.08	5.6
44-35a	Hydrol Humic Latosols	Hilo, normal phases	K6	Onomea	1000	180	Sugar cane	0-6	.32	5.1
35b								6-12	.16	5.4
35c								12-18	.12	5.6
35d								18-24	.14	5.8
35e								24-30	.11	5.8
35f								30-36	.14	5.8
35g								36-42	.11	5.8
35h								42-48	.08	5.8
44-36a	Hydrol Humic Latosols	Hilo, normal phases	K6	Hilo	800	170	Sugar cane	0-6	.34	5.5
36b								6-12	.28	5.9
36c								12-18	.14	6.0
36d								18-24	.42	6.0
36e								24-30	.17	6.0
36f								30-36	.20	5.9
36g								36-42	.10	5.9
36h								42-48	.11	5.8
47-53a	Hydrol Humic Latosols	Hilo, normal phases	K6	Olaa	1600	200	Sugar cane	0-6	.16	5.6
53b								6-12	.13	5.9
53c								12-18	.07	6.2
53d								18-24	.13	6.2
53e								24-30	.15	6.2
53f								30-36	.05	6.3
53g								36-42	.06	6.3
53h								42-48	.06	6.3

TABLE 1 (Continued)

Lab. No.	Soil Group	Soil Family	Symbol	Plantation	Eleva- tion (feet)	Mean Annual Rain- fall (inches)	Vegeta- tion	Depth (inches)	Potas- sium (m.e./ 100 gm.)	pH
47-38a	Hydrol Humic Latosols	Hilo, normal phases	K6	Olaa	650	150	Sugar cane	0-6	.34	5.7
38b	6-12	.19	6.0
38c	12-18	.16	6.1
38d	18-24	.20	5.9
38e	24-30	.13	6.1
38f	30-36	.14	6.1
38g	36-42	.11	6.0
38h	42-48	.06	6.0
47-46a	Hydrol Humic Latosols	Hilo, very shallow phases	K6v	Olaa	250	140	Sugar cane	0-6	.25	5.7
46b	6-12	.10	6.1
46c	12-18	.05	6.3
46d	18-24	.08	6.2
46e	24-30	.10	6.2
46f	30-36	.25	6.1
46g	36-42	.10	6.2
44-28a	Hydrol Humic Latosols	Akaka, normal phases	K8	Laupahoehoe	1500	150	Sugar cane	0-6	.30	5.0
28b	6-12	.13	5.4
28c	12-18	.17	5.4
28d	18-24	.17	5.4
28e	24-30	.16	5.4
28f	30-36	.10	5.4
28g	36-42	.10	5.4
28h	42-48	.14	5.3
44-32a	Hydrol Humic Latosols	Akaka, normal phases	K8	Pepeekeo	1400	230	Sugar cane	0-6	.25	5.2
32b	6-12	.20	5.2
32c	12-18	.07	5.6
32d	18-24	.09	5.5
32e	24-30	.12	5.5
32f	30-36	.09	5.6
32g	36-42	.06	5.7
32h	42-48	.06	5.5

TABLE 1 (Continued)

Lab. No.	Soil Group	Soil Family	Symbol	Plantation	Elevation (feet)	Mean Annual Rain- fall (inches)	Vegeta- tion	Depth (inches)	Potas- sium (m.e./ 100 gm.)	pH
44-25a	Hydrol Humic Latosols	Akaka, normal phases	K8	Pepeekeo	2000	240	Forest	0-6	.17	4.4
25b	6-12	.08	4.9
25c	12-18	.02	5.3
25d	18-24	.01	5.4
25e	24-30	.04	5.2
25f	30-36	.05	5.3
25g	36-42	.06	5.5
25h	42-48	.06	5.4
4-34a	Hydrol Humic Latosols	Akaka, normal phases	K8	Onomea	1500	215	Sugar cane	0-6	.19	4.9
34b	6-12	.16	5.2
34c	12-18	.12	5.4
34d	18-24	.11	5.7
34e	24-30	.15	5.6
34f	30-36	.13	5.7
34g	36-42	.12	5.7
34h	42-48	.08	5.5
44-33a	Hydrol Humic Latosols	Akaka, normal phases	K8	Onomea	1600	215	Forest	0-6	.20	4.8
33b	6-12	.11	5.0
33c	12-18	.13	5.3
33d	18-24	.08	5.4
33e	24-30	.08	5.6
33f	30-36	.06	5.4
33g	36-42	.10	5.3
33h	42-48	.10	5.5
47-18a	Hydrol Humic Latosols	Kealakekua, normal phases	K10	Hutchinson	2500	80	Sugar cane	0-6	.67	5.6
18b	6-12	.29	5.9
18c	12-18	.22	6.0
18d	18-24	.20	6.1
18e	24-30	.15	6.2
18f	30-36	.08	6.2
18g	36-42	.15	6.1
18h	42-48	.11	6.0

TABLE 1 (Continued)

Lab. No.	Soil Group	Soil Family	Symbol	Plantation	Eleva- tion (feet)	Mean Annual Rain- fall (inches)	Vegeta- tion	Depth (inches)	Potas- sium (m.e./ 100 gm.)	pH
47-26a	Lithosols	Rockland—Thin Ash	L2A	Hutchinson	1200	55	Sugar cane	0-6	1.38	6.1
26b								6-12	.15	6.2
26c								12-18	.12	6.3
26d								18-24	.08	6.6
37-30a	Reddish Prairie Soils	Naalehu, normal phases	C3	Hutchinson	500	55	Sugar cane	0-6	6.41	6.3
30b								6-12	5.58	6.7
30c								12-18	4.37	6.9
30d								18-24	3.11	7.1
30e								24-30	2.48	7.0
30f								30-36	2.63	7.0
30g								36-42	3.02	7.0
30h								42-48	3.91	7.0
44-22a	Low Humic Latosols	Kohala, normal phases	N5	Kohala	150	40*	Sugar cane	0-6	1.85	6.1
22b								6-12	1.72	6.5
22c								12-18	1.12	6.9
22d								18-24	.09	6.8
22e								24-30	.08	6.8
22f								30-36	.09	6.7
22g								36-42	.10	6.8
22h								42-48	.10	6.9
44-23a	Low Humic Latosols	Kohala, normal phases	N5	Kohala	600	50	Sugar cane	0-6	.26	5.3
23b								6-12	.43	5.3
23c								12-18	.21	5.3
23d								18-24	.13	5.7
23e								24-30	.11	5.8
23f								30-36	.07	5.8
23g								36-42	.07	5.7
23h								42-48	.08	5.9

TABLE 1 (Continued)

Lab. No.	Soil Group	Soil Family	Symbol	Plantation	Elevation (feet)	Mean Annual Rain- fall (inches)	Vegeta- tion	Depth (inches)	Potas- sium (m.e./ 100 gm.)	pH
44-21a	Low Humic Latosols	Kohala, normal phases	N5	Kohala	1200	70	Sugar cane	0-6	3.60	5.7
21b								6-12	3.57	5.8
21c								12-18	4.51	6.0
21d								18-24	1.26	6.2
21e								24-30	.07	6.3
21f								30-36	.08	6.5
21g								36-42	.10	6.5
21h								42-48	1.23	6.6
44-20a	Low Humic Latosols	Kohala, normal phases in dissected areas	N5D	Kohala	250	60	Sugar cane	0-6	.24	5.0
20b								6-12	.17	5.5
20c								12-18	.07	5.8
20d								18-24	.08	5.8
20e								24-30	.08	5.5
20f								30-36	.07	5.1
20g								36-42	.05	5.1
20h								42-48	.06	5.0
44-18a	Low Humic Latosols	Kohala, normal phases in dissected areas	N5D	Kohala	900	90	Sugar cane	0-6	.19	5.3
18b								6-12	.16	5.2
18c								12-18	.08	5.4
18d								18-24	.04	5.4
18e								24-30	.04	5.4
44-19a	Low Humic Latosols	Kohala, normal phases in dissected areas	N5D	Kohala	925	90	Sugar cane	0-6	.19	5.5
19b								6-12	.15	5.8
19c								12-18	.10	5.8
19d								18-24	.12	5.9
19e								24-30	.12	5.9
19f								30-36	.10	5.9
19g								36-42	.06	5.9
19h								42-48	.08	5.9

Sunlight and Sugar Yields

By R. J. Borden

Crop measurements made in many of our previous cane growth studies have seldom included sufficient climatological data to allow a good study of the relationships of sunlight and temperature to cane and sugar yields. Hence, although one of our projects¹ had not included such a study in its original objective, we find some rather interesting comparisons among the data that were collected.

Measurements and analyses were made at harvest from three separate plant crops of 32-8560 cane that were grown in 16-inch concrete pots with the same amounts of well-mixed Manoa soil,

similarly fertilized and irrigated, and located in the same area at Makiki. All growing conditions except their respective 12-month seasonal growth periods were similar for the three crops.

Sunlight records associated with the total 12 months growing periods of these three crops of cane, and showing sunlight measurements in terms of hours of sunshine (from a blueprint sunshine recorder), day-degrees (from maximum temperature readings), and gram calories (from a pyrliometer) were obtained from the Department of Climatology. These are summarized in **Table 1**.

TABLE 1 SUNLIGHT RECORDS

Crop No.	Growing Period (12 mos.)	Total hours sunshine	Total day-degrees	Total gram calories
1	June 1941-42.....	2978	4542	191,381
2	March 1944-45.....	3228	4730	202,892
3	October 1946-47.....	3002	4549	184,106

Relationships between these three measurements of sunlight show quite general agreement. For instance—

- The ratio of total day-degrees to hours of sunlight for these three crops is 1.53, 1.47, and 1.51, respectively.
- Ratios of total gram calories to hours

of sunlight are 64.3, 62.8, and 61.3.

- And corresponding ratios for gram calories to day-degrees are 42.2, 42.9, and 40.5.

Measurements and analyses made on the three crops of cane are summarized in **Table 2**.

¹ Project A 105—Nos. 161, 161.1, 161.2.

Inspection of these data show that the best cane and sugar yields and the best cane quality came from the second crop, the one with the March to March growing period which received the greatest total amount of sunlight.

Yields and quality from the first and

third crops were not significantly different, and this fact is quite in line with the similar amounts of sunlight that they received. The second crop apparently made more efficient use of its sunlight than the other two crops; this is shown in the following relationships—

SUGAR

	1st Crop	2nd Crop	3rd Crop
Pounds per 1000 hours sunshine.....	.24	.33	.22
Pounds per 1000 day-degrees.....	.16	.22	.17
Pounds per 100,000 gram calories.....	.37	.52	.41

Expressed in another way, this shows that a unit of sunlight measurement did not result in the same yield of sugar from cane crops in different seasons even when the cultural conditions were similar. It has been suggested that this may be due to differences in areas of the active leaf surfaces available to receive sunlight. Although lear areas were not measured in these tests, the three crops showed

considerable similarity in their total weights of tops and trash which are the plant parts chiefly involved with sunlight relationships. In fact, quite contrary to the differences we found in the efficiency on sugar yields, sunlight efficiency on amounts of tops and trash was remarkably similar for all three crops. e.g.—

TOPS AND TRASH

	1st Crop	2nd Crop	3rd Crop
Grams dry wt. per 1000 hours sunshine.....	155	150	141
Grams dry wt. per 1000 day-degrees.....	101	102	93
Grams dry wt. per 100,000 gram calories.....	241	238	230

There are several other points of interest from the data in **Table 2**, although they do not appear to be related to the differences in sunlight which the three crops received. Concentration or percentage of total nitrogen in juice and bagasse from the millable stalks which were similarly crushed, was 30 per cent higher in the third than in the second crop, but total grams of nitrogen in these stalks were almost identical. Both percentages and total amounts of nitrogen in stalks were lowest in the first crop,

even though soil and fertilization were the same for all three crops.

In the trash collected during the growing periods plus the green tops at harvest, the amounts of dry matter, percentage nitrogen, and total grams of nitrogen were quite similar for the first and second crops, but the third crop had a slightly lower total amount with a somewhat higher nitrogen concentration.

Roots and stubble from the third crop were heaviest and had both the highest percentage and total amount of nitrogen.

In the first and second crops weights of roots and stubble and their nitrogen status were quite similar.

Combining these separate weights and analyses, it is found that there has been considerable difference in the amounts of total nitrogen recovered from identical supplies given to these three crops. The first crop showed a 61 per cent recovery of its known available nitrogen supply;

the second and third crops recovered 80 and 94 per cent, respectively. Since no nitrogen was lost by leaching in these tests, it is believed that these differences in nitrogen recovery are the effects of soil differences which either tied up or released soil nitrogen during the crop, but apparently there was no direct relationship between these soil nitrogen effects and sunlight.

TABLE 2 CANE CROP MEASUREMENTS

Details and Measurements* Growth period (12 months)	1st Crop June 1941-42	2nd Crop March 1944-45	3rd Crop October 1946-47
Millable cane stalks (gms. grn. wt.).....	2115	2816	2195
Millable cane stalks (gms. dry wt.).....	646	882	681
% moisture in millable stalks.....	69.4	68.7	68.9
Brix of crusher juice.....	21.2	23.5	22.3
Pol of crusher juice.....	19.7	21.9	20.5
Purity of crusher juice.....	92.9	93.2	91.7
Yield % Cane.....	15.3	17.0	15.8
Grams recoverable sugar.....	322	477	345
% N in millable stalks.....	.172	.287	.373
Grams N in millable stalks.....	1.109	2.529	2.540
Tops and trash (gms. dry wt.).....	461	483	423
% N in tops and trash.....	.399	.382	.467
Grams N in tops and trash.....	1.838	1.850	1.987
Roots and stubble (gms. dry wt.).....	192	172	255
% N in roots and stubble.....	.627	.643	.750
Grams N in roots and stubble.....	1.204	1.111	1.913
Total dry wt. (grams).....	1299	1536	1359
Grams N in total dry weight.....	4.151	5.490	6.437
% total N** recovered in crop.....	61.4	80.2	94.0

*Averages from nine replicates in first crop, and from 18 replicates in second and third crops.
 **Available N in soil plus that added in fertilizer.

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